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Link among energy consumption, carbon dioxide emission, economic growth, population, poverty, and forest area

Evidence from ASEAN country

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Abstract

Purpose – The purpose of this paper is to investigate the relationship among energy consumption (EC), carbon dioxide emission, economic growth, foreign direct investment, population, poverty, and income of four Association of South East Asian Nations (ASEAN) countries, namely, Malaysia, Singapore, Brunei, and the Philippines.

Design/methodology/approach – An econometric analysis was used to achieve the goal of this study taking the period of 1995-2014.

Findings – The results of the study motivated the researcher to recommend that four ASEAN countries, namely, Malaysia, Singapore, Brunei, and the Philippines should increase their energy efficiency, increase the share of green energy from their total energy use, and increase energy conservation in order to reduce the unnecessary wastage of energy.

Originality/value – The findings validate that economic growth, population, and income have positive and statistically significant impacts on EC, while carbon dioxide emission, foreign direct investment and poverty have negative impacts on EC for Malaysia. Economic growth, income and poverty have positive and statistically significant impacts on EC, while carbon dioxide emission, foreign direct investment and population have negative impacts on EC for Singapore. Carbon dioxide emission and foreign direct investment have positive and statistically significant impacts on EC, while economic growth, population, poverty and income have negative impacts on EC for the Philippines. Finally, economic growth, carbon dioxide emission and income have positive and statistically significant impacts on EC, while foreign direct investment, population and poverty have negative impacts on EC for Malaysia.

Keywords Population, Poverty, Economic growth, Energy consumption, Carbon dioxide emission, Forest area

Paper type Research paper

1. Introduction

Nowadays, there is a growing concern about the global warming issues that are mainly arising from the large amount of the world-wide carbon dioxide (CO_2) emissions. This has always happened in developing countries. However, the developed countries have been asked to reduce their domestic CO_2 emissions to a certain level. Based on Kraft and Kraft (1978), there is a causality relationship between the energy consumption (EC) and income. As we all know that the CO_2 emissions are a main cause of the global warming not only in Association of South East Asian Nations (ASEAN) countries but also all around the world.

So, it is so important for us to analyze the linkage between the EC, carbon dioxide emission, economic growth, foreign direct investment, population, poverty, and income. This is because EC and CO_2 emissions are completely related to the economic growth of all countries. Besides that, all of these variables are actually related with each another (John, 2000).

The linkages among EC, economic growth, relative price, foreign direct investment, and financial development (FD) in Malaysia are examined by Tang and Tan (2012). Malaysia is an

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energy-intensive country where we can see that energy is an important input for the development of the financial sector of Malaysia. Besides that, Tang (2008) mentioned that Malaysia is the second highest electricity consumer among the ASEAN countries. The energy developments are also a determinant factor of economic growth and development.

EC, considered a fundamental driver of output, has a significant role in economic growth and development. It is a vital component in economic growth either directly or as a complement to other factors of production. Energy demand can influence international trade, while trade can also influence energy demand. In the first case, energy demand can influence trade because energy is an imperative input into the production and shipping of goods intended for international trade (Abidin *et al.*, 2015).

Household EC refers to the amount of energy resources that are being used by households on various appliances. The household EC pattern can be majorly categorized into dimensions such as cooking, lightening, heating and cooling, as well as transportation purposes. An analysis of the pattern and determinant of household EC has been the focus of previous studies with different tools of econometric analysis, depending on the scope of the dimension of household EC covered by a study (Danlami *et al.*, 2015).

A study on CO_2 emissions can be categorized into three main groups. The first category comprises studies that tested the validity of Environmental Kuznet Curve (EKC) hypothesis. The second category comprises those studies that laid emphasis on the relationship between economic growth and CO_2 emissions. The third category comprises those studies that laid emphasis on the simultaneous impacts of GDP and EC on CO_2 emissions (Danlami *et al.*, 2017a).

This study attempts to analyze the relationship among the EC, carbon dioxide emission, economic growth, foreign direct investment, population, poverty, and forest area for the ASEAN countries. A lot of research has been conducted about the energy policy, the linkage among EC, economic growth, relative price, foreign direct investment, and FD in Malaysia, as well as economy consumption, economic growth and applied energy in Korea; however, this analysis is limited to the ASEAN countries.

2. Literature review

This paper extends this literature to consider the link between EC, carbon dioxide emission, economic growth, foreign direct investment, population, poverty, and income based on evidence from the ASEAN which includes Malaysia, the Philippines, Singapore, and Thailand. These four countries are the most influential members of ASEAN in the twenty-first century.

Lau *et al.* (2014) found from the bounds test that there is no long-run relationship among carbon dioxide emission, institutional quality, and economic growth in Malaysia between 1984 and 2008. However, Granger causality tests shows that the institutional quality is found to affect not only economic growth but also carbon dioxide emissions. The benefit of this analysis might help Malaysia to achieve high economic growth without sacrificing its environment. From this paper, we can conclude that there is a positive interaction between carbon dioxide and institutional quality indicator which shows the importance of domestic institution framework in controlling carbon dioxide emission in the development process. So, in order to overcome carbon dioxide emission in the country, policy makers should regulate and enhance the role of domestic institutions.

Tang and Tan (2012) addressed the linkages among EC, economic growth, relative price, foreign direct investment, and FD in Malaysia between 1972 and 2009. They used Johansen cointegration test and bounds testing approach and found that EC and economic growth Granger causes each other either in short or long runs. Even though energy is a prominent resource for financial sector for development in Malaysia, they found that EC Granger causes FD. To overcome this problem, the policy makers should establish a dual strategy that first increases investment in the energy infrastructure in order to make sure that the supply of energy is sufficient for both the financial sector and economic development and second encourages R&D in green technology so that the consumption of fossil fuels is reduced. Hence, the environmental problem can be minimized without affecting the economic growth and FD in Malaysia. However, the inflow of FDI and FD should be taken into consideration when implementing new policies. Effective banking system reforms would lead to efficient financial systems so that they can fulfill the demand for energy by providing the loan and credits. Renewable energy and green technology can attract foreign investors to invest in Malaysia in order to boost economic growth.

Lean and Rusell (2010) discussed carbon dioxide emission, electricity consumption, and output in ASEAN countries. Their research is within a panel vector error correction. They chose five ASEAN countries between 1980 and 2006. They estimated that there is a statistically significant positive association between electricity consumption and emission, while there is a non-linear relationship between emission and real output with a consistent EKC in the long run. The Granger causality test recommended that, in the long run, there is a unidirectional Granger causality running from electricity consumption and emission to economic growth. Besides that, in the short run, there is also a unidirectional Granger causality running from emissions to electricity consumption.

Pao and Tsai (2010) investigated the carbon dioxide emissions, EC and economic growth in BRIC countries from 1971 until 2005 but in Russia between 1990 and 2005. In the article, they said that there is a positive consumption and statistically significant impact on emissions in the long run. However, the real outputs show the inverted U-shape pattern associated with the EKC hypothesis with 5.393 (in logarithms) of threshold income. While in the short run, changes of emission are caused by the error correction term and short term of EC stocks, as against short run output shocks for each country. They conclude that in order to overcome the problem of emissions and to not adversely affect economic growth, they recommend to increase both energy supply investment and energy efficiency, and boost up energy conservation policies in order to reduce wastage of energy that can be initiated for energy-dependent BRIC countries.

Usama *et al.* (2013) examined the link between EC, carbon dioxide emission, and economic growth in Latin America and the Caribbean region. They used the Canonical Cointegrating Regression for conducting analysis between 1980 and 2008. From the findings, the researchers suggested that these countries that have positive bidirectional long-run relationship between EC, carbon dioxide emission, and economic growth should increase their energy efficiency and also increase the share of green energy from their total energy use and increase energy conservation in order to overcome the reduction of unnecessary waste of energy. Biomass as the source of cooking fuel is one of the causes of indoor air pollution, desertification, soil erosion, and other visual problems. Analyzing the patterns of household energy use in Bauchi State can enable the relevant authorities to have a clear picture and understand the factors that can shape the pattern of household energy choice in the state in order to encourage the households to adopt cleaner energy sources (Danlami *et al.*, 2017b).

Alshehry and Belloumi (2015) investigated the dynamic causal relationships between EC, energy price, and economic activity in Saudi Arabia based on a demand side approach. They used a Johansen multivariate cointegration approach and incorporated CO_2 emissions as a control variable. The results indicate that there exists at least a long-run relationship between EC, energy price, carbon dioxide emissions, and economic growth. Furthermore, a long-run unidirectional causality stands from EC to economic growth and CO_2 emissions, a bidirectional causality from carbon dioxide emissions to economic growth, and a long-run unidirectional causality runs from energy price to economic growth and CO_2 emissions. In the short run, there is a unidirectional causality running from CO_2 emissions to EC and economic output and from energy price to CO_2 emissions.

Lin and Moubarak (2013) explored the relationship between renewable EC and economic growth in China for the period 1977-2011. Autoregressive Distributed Lag approach (ARDL) to cointegration and Johansen cointegration techniques are employed by including intermittent variables, namely, carbon dioxide emissions and labor. They employed Granger causality test in order to determine the direction of the causality among the variables. The results showed that there was a bidirectional long-term causality between renewable EC and economic growth. This finding implied that growing economy of China was propitious for the development of the renewable energy sector which in turn helps to boost economic growth. They also found that labor influenced renewable EC in the short term.

Begum *et al.* (2015) addressed the dynamic impacts of GDP growth, EC and population growth on CO_2 emissions using econometric approaches for Malaysia. Empirical results from the ARDL bounds testing approach showed that over the period of 1970-1980, per capita CO_2 emissions decreased with increasing per capita GDP (economic growth); however, from 1980 to 2009, per capita CO_2 emissions increased sharply with a further increase of per capita GDP.

3. Methodology

In this paper, the time series data collected between the period 1995 and 2014 were used which correspond to 20 years. These data were collected from four member countries of ASEAN which are Malaysia, Philippine, Brunei, and Singapore. There are seven variables used in this study, which are EC (kg), carbon dioxide emission (metric tons), economic growth (percent), population (million), poverty (percent), and forest area (million hectare). To estimate the relationship between these variables, linear regression equations for each country are specified as follows:

$$\mathrm{EC}_t = \beta_0 + \beta_1 \mathrm{CO}_{2t} + \beta_2 \mathrm{GDP}_t + \beta_3 \mathrm{FA}_t + \beta_4 \mathrm{PPL}_t + \beta_5 \mathrm{POV}_t \tag{1}$$

where EC_t is the energy consumption; CO_{2t} the carbon dioxide emission; GDP_t the economic growth; PPL_t the population; POV_t the poverty; and FA_t the forest area.

Linear regression method with SPSS was used to test the relationship between the variables. There are a few steps involved in estimating the relationship between variables. First is to see the correlation between dependent and independent variables, so we used the Model Summary table to test the goodness of fit of the model. Hence, from the table the R^2 value is known which measures the proportion or the percentage of the total variation in the dependent variable explained by the regression model.

Second is by using ANOVA to determine whether the significant differences exist between variable scores. ANOVA helps in comparing the dependent variable score that corresponds to each dependent variable category. We used the F-test and p-value to test the significance of the model. If the p-value is less than 0.05, the model is considered as statistically significant. Third is to use the coefficient table in order to see the β coefficient for the actual regression.

3.1 Model specification tests

There are a variety of tests that can be utilized to analyze the data such as augmented Dickey-Fuller (ADF) unit root test, Phillips and Perron (PP) unit root test, Johansen cointegration test and Granger causality test. All the tests are carried out by employing E-Views econometric software to analyze the data. The analysis of the data requires running a series of tests in sequence. The initial test involves applying the ADF and PP unit root test to check the stationarity of the variables in the equation. Johansen cointegration test is used to determine the cointegrating relationship of the unit roots in the residuals. While Granger causality test is used to measure the ability to predict the future values by using another time series.

3.1.1 ADF unit root test. According to Dickey and Fuller (1981), an ADF test is a unit root test for time series sample data. This test is used to determine the stationarity stage and reduce the first differences variation of all the variables before continuing with the empirical analysis. The presence of ADF is required to solve the problems in Dickey-Fuller (ADF) test which assumes that there is no autocorrelation in first differences under a null hypothesis. If the *t*-statistic value is greater than the ADF critical value, the null hypothesis will be rejected. We can conclude that there is no unit root problem and stationary series when the null hypothesis is rejected. The null hypothesis is accepted if the *t*-statistic value is less than the ADF critical value which means there is a unit root problem and non-stationary series.

3.1.2 PP unit root test. According to Phillips and Perron (1988), PP method is used to test the stationarity stage in the regression equation besides the ADF test for the unit roots problem existence and to determine the integration order among these variables. Newey and West (1987) method is applied to determine the optimal lengths of lag. PP unit root test is well known for the analysis of the financial time series data. PP unit root test varies from the ADF unit root test. The benefit of PP unit root test is that it is non-parametric. For instance, there is no request for selecting the level of autocorrelation as in ADF. In contrast, this method is based on the asymptotic theory which is the primary disadvantage of this test. This method is only suitable for large samples and it shares the weakness of the ADF in terms of its sensitivity to structural breaks which result in small and poor sample often ending with the presence of unit root.

3.1.3 Johansen cointegration test. Cointegration is defined as the changes of the individual variables caused by the developments. When multiple individual time series variables are found integrated with each other, Johansen cointegration test will be used to determine whether the long-term relationships exist among the variables in the model (Johansen and Juselius, 1990). According to Johansen and Juselius (1990), Johansen cointegration test is used to determine the stability of long-term relationships among the variables. The null hypothesis shows that there are no cointegrating equations while the alternative hypothesis shows that there are cointegrating equations.

3.1.4 Granger causality test. According to Engle and Granger (1987), Granger causality test is used to test the significance of the coefficients which are used as the explanatory variables in the regression. The Granger causality test indicates the existence of causality between the variables, i.e. it finds out whether there is a relationship between all the variables or not. The strength of Granger causality can change over time and the causality direction will change depending on time. A bidirectional causality can be formed.

4. Results and discussion

Table I shows the results of SPSS output by using the linear regression method. The results show the relationships between EC (kg), carbon dioxide emission (metric tons), economic growth (percent), foreign direct investment (US$), population (million), poverty (percent), and income (percent) in Malaysia, the Philippines, Brunei, and Singapore. Summary of the empirical evidence result for all the four countries is reported in Table I. As we can see, the result for Malaysia and the Philippines is technically, theoretically and statically acceptable because the explanatory power of R^2 and adj. R^2 is high and there is no serial correlation problem as shown by Durbin Watson (D-W) test. However, for Brunei and Singapore, the explanatory power of R^2 and adj. R^2 is relatively lower than 0.6 which are 0.578 and 0.375 for R^2 and 0.383 and 0.086 for adj. R^2, respectively. It shows that there is a serial correlation problem.

For Malaysia, the R^2 is 0.951, which means that 95.1 percent of the variability is explained by the independent variables, which are carbon dioxide, economic growth, foreign direct investment, population, poverty and income, and 95.1 percent of the variability is

Table I.
Regression result

Variables/Country	Malaysia	The Philippines	Brunei	Singapore
Intercepts	151.856 (0.170)	911.440 (6.402)	14524.119 (0.638)	−64.632 (−0.004)
CO_2	−8.215 (−0.124)	139.496 (1.877)	164.187 (2.210)	−5.914 (−0.054)
GDP	3.218 (0.377)	−1.865 (−1.346)	181.860 (1.755)	11.088 (0.200)
FA	−1.495E-9 (−0.108)	2.126E-9 (0.856)	−1.326E-6 (−0.738)	−2.953E-9 (−0.155)
PPL	9.961E-5 (3.562)	−1.576E-7 (−0.208)	−0.030 (−0.531)	−0.001 (−0.430)
POV	−61.877 (−1.604)	−6.663 (−1.743)	−754.700 (−0.474)	482.502 (0.700)
EC	18.809 (1.169)	−68.440 (−2.728)	579.184 (0.346)	712.095 (0.103)
R^2	0.951	0.901	0.578	0.375
Adj. R^2	0.928	0.855	0.383	0.086
D-W	1.779	1.742	1.494	2.144
F-stat.	41.845	19.643	2.964	1.300
Prob.	0.000	0.000	0.047	0.324

Note: Figures in parentheses () are *t*-ratios significant at 5 percent level

explained by the dependent variable, which is EC. While for the Philippines, Brunei, and Singapore, the R^2 is 90.1 percent, 57.8 percent and 37.5 percent, respectively, at 5 percent level of significance. Besides that, the *F*-ratio is found to be insignificant. It implies that all the independent variables used in the model do not jointly influence the dependent variable that is EC in this paper.

The estimates of linear regression indicate that the EC is positively related to carbon dioxide emission in the Philippines and Brunei. It respectively shows that 1 metric tons increase in carbon dioxide emission will lead to an increase in the EC by 139.496 and 164.187 kg for the Philippines and Brunei, respectively. Meanwhile, Malaysia and Singapore show a negative relationship with EC. The result shows that 1 metric tons increase in the carbon dioxide emission will reduce the EC by 8.215 and 5.914 kg for Malaysia and Singapore, respectively.

Next variable is economic growth. This variable shows a positive relationship with EC in Malaysia, Brunei, and Singapore. It shows that a 1 percent increase in the economic growth will lead to an increase in the EC by 3.218, 181.860 and 11.088 kg in Malaysia, Brunei, and Singapore, respectively. But in the Philippines, a 1 percent increase in economic growth will reduce the EC by 1.865 kg.

For forest area, it indicates a positive relationship between forest area and EC in the Philippines. It shows that a US$1 increase in the foreign direct investment will increase the EC by 2.126E-9 kg. However, Malaysia, Brunei, and Singapore show a negative relationship. It means that every US$1 increase in the forest area will lead to a decrease in the EC by 1.495E-9, 1.326E-6, and 2.953E-9 kg for Malaysia, Brunei, and Singapore, respectively.

The estimated coefficient of population mostly shows a negative relationship between population and EC. But for Malaysia, it shows a positive relationship. It means that one million increase in the population will lead to an increase in EC by 9.961E-5 kg. In the meanwhile, the result shows that one million increase in the population will reduce the EC in the Philippines, Brunei, and Singapore by 1.576E-7, 0.03 and 0.001 kg, respectively.

For the variable poverty, it shows a negative relationship with the EC in Malaysia, the Philippines, and Brunei. The result shows that a 1 percent increase in the poverty rate will lead to a reduction in the EC by 61.877, 6.663, and 754.700 kg in Malaysia, the Philippines, and Brunei, respectively. However, we found that there is a positive relationship between the poverty rate and EC in Singapore. It shows that a 1 percent increase in poverty will also increase the EC by 482.502 kg.

Finally, we consider EC. This variable shows a positive relationship between the income and EC in Malaysia, Brunei, and Singapore. The result shows that a 1 percent increase in the EC will lead to an increase in CO_2 by 18.809, 579.184, and 712.095 kg in Malaysia, Brunei, and Singapore, respectively. But in the Philippines, it shows a negative relationship between CO_2 and EC. A 1 percent increase in CO_2 will reduce the EC by 68.440 kg.

Hence, from the Table I, the full regression model in the Malaysia, the Philippines, Brunei, and Singapore, respectively, can be written as follows:

$$EC_t = 151.856 - 8.215CO_{2t} + 3.218GDP_t - 1.495E{-}9FA_t + 9.961E{-}5PPPL_t - 61.877POV_t$$

$$EC_t = 911.440 + 139.496CO_{2t} - 1.865GDP_t + 2.126E - 9FA_t - 1.576E{-}7PPL_t - 6.663POV_t$$

$$EC_t = 14524.119 + 164.187CO_{2t} + 181.860GDP_t - 1.326E{-}6FA_t - 0.03PPL_t - 754.700POV_t$$

$$EC_t = -64.632 - 5.914CO_{2t} + 11.088GDP_t - 2.953E{-}9FA_t - 0.001PPL_t + 482.502POV_t$$

4.1 Stationarity test

Stationarity test is necessary to confirm whether the data are stationary or non-stationary, and to determine the number of unit roots at different levels. The first step is to test time series variables for their stationarity. Therefore, two different stationarity tests were applied which are the ADF test suggested by Dickey and Fuller (1981) and PP unit root test suggested by Phillips and Perron (1988).

These two tests were performed to test whether the data are stationary or non-stationary and to determine the number of unit roots at their level. The null hypothesis which states that the variable has unit root which is non-stationary will be rejected if the p-value is less than 5 percent and the absolute value of t-statistic value is higher than the absolute value of critical value. The results of the stationarity test are presented in Table II.

Based on the ADF and PP unit root tests, the results reveals that only the GDP indicator is significant at 1 and 5 percent level of significance which rejects the null hypothesis stating that the variable has unit root which is non-stationary on levels, because the absolute value of t-statistic value is higher than the absolute value of critical value which is $|-6.318197| > |-3.467703|$ in the ADF test. GDP indicator in the PP test also showed the same result that rejects the null hypothesis which states that the variable has a unit root which is non-stationary because the absolute value of the t-statistic value is higher than the absolute value of the critical value on level which is $|-6.349947| > |-2.899115|$. So, the GDP indicator does not have a unit root which is stationary.

	On levels		On first differences	
	Intercept and trend		Intercept and no trend	
Variables	ADF	PP	ADF	PP
CO_2	−3.062407**	−3.180102**	−8.659890***	−8.692524***
EC	−3.027208**	−3.097366**	−9.302569***	−9.309800***
GDP	−6.318197***	−6.349947***	−8.842762***	−8.842766***
PPL	−1.729354**	−1.759618**	−8.842762***	−8.842766***
POV	−2.418980**	−2.510149**	−8.555658***	−8.552360***
FA	−1.631576**	−1.631576**	−8.795390***	−8.795287***

Notes: The critical values for unit root tests at 1 and 5 percent significance levels are −4.078426 and −3.467703 (intercept and with trend), −3.516676 and −2.899115 (intercept and no trend), respectively, for both the augmented Dickey-Fuller (ADF) and Phillips Perron (PP) tests; Lag length is selected automatically based on SIC, maxlag = 4 for augmented Dickey-Fuller (ADF) and bandwidth is selected automatically based on Newey-West automatic test using Bartlett kernel for Phillips Perron (PP) test. **,***Statistically significant at 5 and 1 percent levels, respectively

Table II. Unit root results

Other variables such as CO_2, EC, PPL, POV, and FA indicators show that the results are not significant at 1 and 5 percent level of significance which rejects the null hypothesis stating that the variable has unit root, which is non-stationary on levels. This is because the absolute value of the *t*-statistic value is lower than the absolute value of the critical value in the ADF test and PP test.

For example, the absolute value of the *t*-statistic value of CO_2 emission is lower than the absolute value of the critical value on levels in ADF test which is $|-3.062407| < |-3.467703|$; the null hypothesis that states that the variable has unit root which is non-stationary is not rejected. CO_2 emission indicator in the PP test also showed the same result that the null hypothesis which states that the variable has unit root which is non-stationary on levels is not rejected, because the absolute value of the *t*-statistic value is lower than the absolute value of the critical value on levels which is $|-6.349947| < |-2.899115|$. So, CO_2 emission is the variable that has a unit root which is non-stationary on levels.

But, the absolute value of the *t*-statistic value of CO_2 emission is higher than the absolute value of the critical value on first differences in the ADF test which is $|-8.659890| > |-3.467703|$; the null hypothesis which states that the variable has unit root which is non-stationary on first differences is rejected. CO_2 emission indicator also gets the same result in the PP test. The null hypothesis which states that the variable has unit root which is non-stationary on first differences is rejected, because the absolute value of the *t*-statistic value is higher than the absolute value of the critical value first differences which is $|-8.692524| > |-2.899115|$. Thus, CO_2 emission is the variable that has no unit root which is stationary on first differences.

So, the GDP indicator is the only one variable which does not have a unit root which is stationary. While the CO_2 emission is the variable that has a unit root which is non-stationary. The EC, PPL, POV, and FA variables also have same situations with the CO_2 emission, i.e. they have the unit root which is non-stationary.

4.2 Johansen cointegration test

Johansen cointegration test is used to determine the stability of long-term relationships among the variables. The null hypothesis shows that there are no cointegrating equations while the alternative hypothesis shows that there are cointegrating equations. The result are shown in Table III.

Based on Johansen cointegration test for the carbon dioxide (CO_2) emission, the trace statistic value is higher than the critical value at 5 percent level of significance in the trace test. The results showed that 112.9819 is higher than 95.75366. So, the null hypothesis which states that at most there exists no cointegrating equation is rejected. Then, the *p*-value for the null hypothesis that shows that there is no cointegrating equation is 0.0019, where the *p*-value is less than the critical value ($0.0019 < 0.05$). So, the null hypothesis is rejected that states there is no cointegrating equation.

Hypothesized no. of CE(s)	Eigenvalue	Trace statistic	0.05 critical value	Prob.[b]
None[a]	0.394041	112.9819	95.75366	0.0019
At most 1[a]	0.350203	73.90834	69.81889	0.0227
At most 2	0.269086	40.28294	47.85613	0.2125
At most 3	0.122570	15.83305	29.79707	0.7240
At most 4	0.057158	5.633956	15.49471	0.7383
At most 5	0.013284	1.043124	3.841466	0.3071

Notes: Trace test indicates two cointegrating equations at the 0.05 level. [a]Denotes rejection of the hypothesis at the 0.05 level; [b]*p*-values

Table III.
Result of Johansen cointegration test (trace statistic)

When the null hypothesis that states that at most there exists a cointegrating equation, the trace statistic value is higher than the critical value at 5 percent level of significance in the trace test because 73.90834 is higher than 69.81889. So, the null hypothesis that states that at most there exists a cointegrating equation is rejected. This is because the p-value for the null hypothesis which shows that there is at most a cointegrating equation is 0.0227 where the p-value is less than the critical value ($0.0227 < 0.05$). So, the null hypothesis is rejected that states that there is at most a cointegrating equation.

But the null hypothesis that states that at most there exist two cointegrating equations is accepted because the trace statistic value is lower than the critical value at 5 percent significance level because 40.28294 is lower than 47.85613. So, the null hypothesis that states that at most there exist two cointegrating equations is accepted. Then, the p-value for the null hypothesis which shows that there is at most two cointegrating equations is 0.2125 where the p-value is more than the critical value ($0.2125 > 0.05$). So, the null hypothesis is accepted that states that at most there exist two cointegrating equations.

So, the null hypothesis which states that at most there exists a cointegrating equation is rejected. This means that there is not only one cointegrating equation, until the null hypothesis which states that at most there exist two cointegrating equations is accepted. This means that there are at least two cointegrating equations at 5 percent level of significance.

4.3 Granger causality test

Granger causality test is used to test the significance of the coefficients which are used as the explanatory variables in the regression (Engle and Granger, 1987). The Granger causality test indicates the existence of causality between the variables which is the relationship between all the variables.

Table IV shows the result of Granger causality test. Granger causality test was carried out to study the relationship between carbon dioxide emission and other independent variables. With reference to the results of Granger causality, the null hypothesis for p-values less than the value of 0.05 will be rejected.

In the result of Granger causality test, the null hypothesis assumes only one relationship of carbon dioxide (CO_2) emission, which states that CO_2 does not Granger cause forest area and FA is rejected because the p-value is smaller than 0.05 ($0.0260 < 0.05$). But null hypothesis of one relationship of forest area states that FA does not Granger cause carbon dioxide (CO_2) emission and CO_2 is accepted. That means there is the unidirectional causality from carbon dioxide (CO_2) emission to forest area. For the other variables, there is an independent causality between the variables because their p-values are higher than 0.05, so the null hypotheses are not rejected.

The results implied that a policy aiming at reducing EC and controlling for CO_2 emissions could slow economic growth but not significantly. Thus, any energy conservation measure undertaken should pay considerable attention to the adverse effects on economic growth. ASEAN countries found ways of providing energy services while simultaneously addressing the environmental impacts associated with the different uses of energy.

5. Conclusion

This analysis used annual data from 1995 to 2014 and investigated the relationship among the EC, carbon dioxide emission, economic growth, foreign direct investment, population, poverty, and income between the four ASEAN countries: Malaysia, the Philippines, Singapore, and Brunei. Time series data have been used to see the relationship between the independent variables and the dependent variable for these four ASEAN countries.

From the test results, we can see that the result for Malaysia and the Philippines are accepted technically, theoretically, and statically. It is because the explanatory power of R^2 and adj. R^2 is higher than 0.6 value. Besides that, there is no serial correlation problem as

Null hypothesis	Observation	F-statistic	Probability
EC does not Granger cause CO_2	78	2.34933	0.1026
CO_2 does not cause EC		1.68920	0.1918
FA does not Granger cause CO_2	78	1.90985	0.1554
CO_2 does not cause FA		3.83908	0.0260
GDP does not Granger cause CO_2	78	1.36872	0.2609
CO_2 does not cause GDP		2.15968	0.1227
POV does not Granger cause CO_2	78	0.38451	0.6822
CO_2 does not cause POV		0.01559	0.9845
PPL does not Granger cause CO_2	78	0.85129	0.4311
CO_2 does not cause PPL		1.86206	0.1627
FA does not Granger cause EC	78	0.20352	0.8163
EC does not cause FA		2.07525	0.1329
GDP does not Granger cause EC	78	2.75676	0.0701
EC does not cause GDP		1.82454	0.1686
POV does not Granger cause EC	78	0.54473	0.5823
EC does not cause POV		0.49297	0.6128
PPL does not Granger cause EC	78	0.07006	0.9324
EC does not cause PPL		1.08726	0.3425
GDP does not Granger cause FA	78	0.21217	0.8093
FA does not cause GDP		0.50131	0.6078
POV does not Granger cause FA	78	0.10492	0.9005
FA does not cause POV		0.16721	0.8463
PPL does not Granger cause FA	78	1.12830	0.3292
FA does not cause PPL		0.56952	0.5683
POV does not Granger cause GDP	78	0.06754	0.9347
GDP does not cause POV		2.00545	0.1419
PPL does not Granger cause GDP	78	0.22814	0.7966
GDP does not cause PPL		0.06490	0.9372
PPL does not Granger cause POV	78	0.16152	0.8512
POV does not cause PPL		0.10183	0.9033

Table IV.
Results of Granger causality test

shown by D-W test. However, for Brunei and Singapore the explanatory powers of R^2 and adj. R^2 is relatively lower than 0.6 which are 0.578 and 0.375 for R^2 and 0.383 and 0.086 for adj. R^2, respectively. Thus, both show that there is a serial correlation problem. We can conclude that although Malaysia and the Philippines are less developed than Brunei and Singapore but based on this empirical evidence, we can see that they are more accepted. It is because the explanatory power of R^2 and adj. R^2 is higher than 0.6 value.

Furthermore, we can see that the dependent variables for those countries are related to the dependent variable. For Brunei and Singapore, the results show that there might be some serial correlation problems because they are developed countries. Generally, we know that Singapore and Brunei are developed countries and the Philippines and Malaysia are developing countries.

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